THE HISTORICAL ROLE OF FIRE ON THE BITTERROOT NATIONAL FOREST

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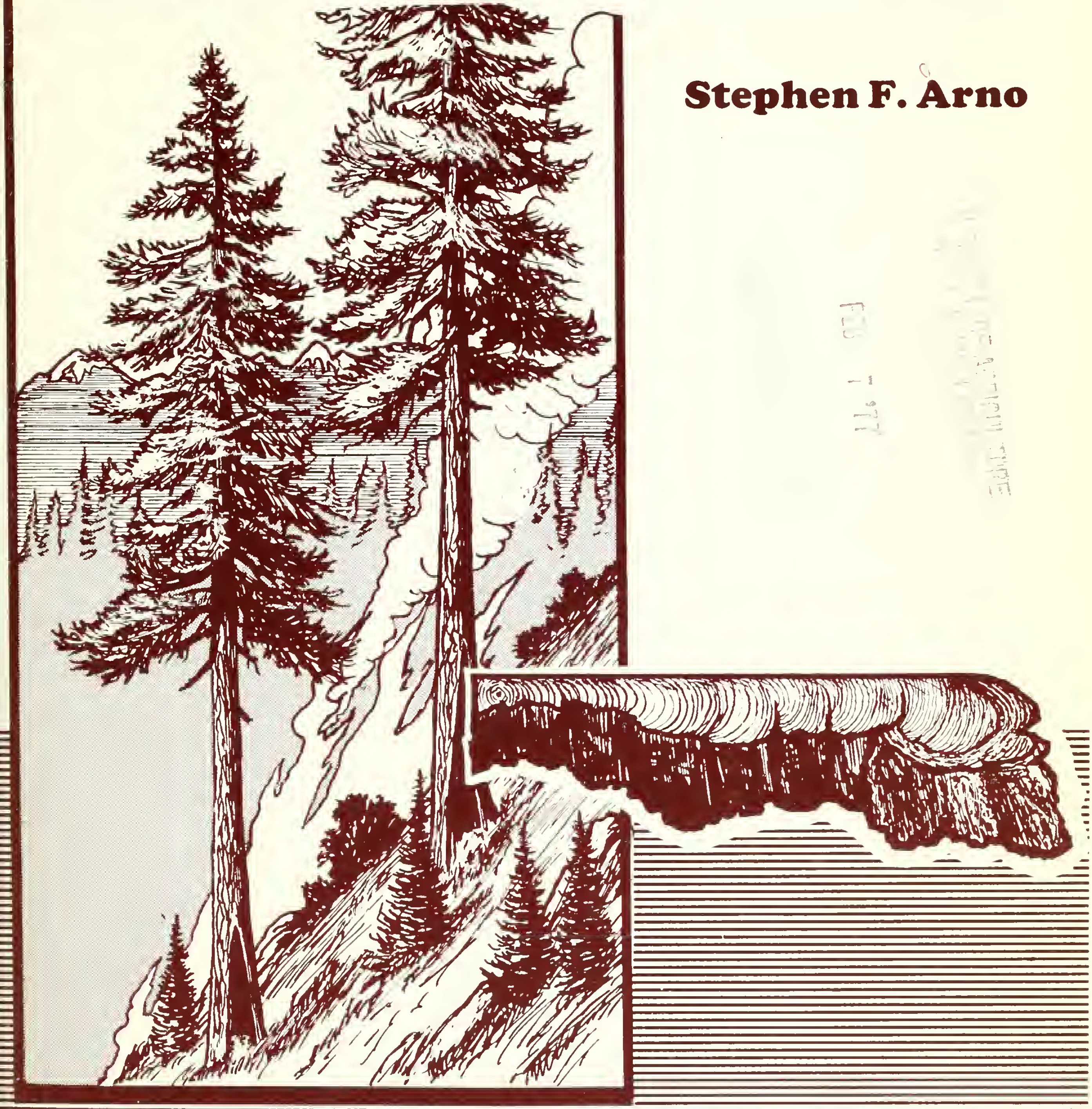

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THE AUTHOR

STEPHEN F. ARNO is an Associate Plant Ecologist on the Forest Ecosystems research work unit at Missoula. He earned a B.S. in forestry at Washington State University and a master's degree and a Ph.D. in forestry and plant science at the University of Montana before joining the USDA Forest Service in 1970. This study was supported by the Fire in Multiple Use Management Research, Development, and Application Program headquartered at the Northern Forest Fire Laboratory in Missoula.

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Forest Service
U.S. Department of Agriculture
Ogden, Utah 84401

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ABSTRACT

Presents frequencies, intensities, and influences of fire on stand structure and composition on the Bitterroot National Forest in west-central Montana. Three study areas were established, each having a wide range of elevations and forest types. Findings are based upon study of nearly 900 individual fire scars on living trees, and on age-classes of shade-intolerant trees attributable to fire.

During the period from 1600 to 1900 fires were frequent in most habitat types, and substantial amounts of forest survived most fires. Some high-intensity stand-destroying fires were also detected in certain habitat types on each study area. Results show that fire was historically a major force in stand development, but that it has been of minor significance during the past 50 years, possibly because of organized fire suppression.

INTRODUCTION

Biologists have long recognized that fire historically has had strong influence on the ecology of Northern Rocky Mountain forests (Intermountain Fire Research Council 1970; Habeck and Mutch 1973). However, there is little data on frequency and severity of fires in the various forest types before organized fire suppression evolved in the early 1900's. Thus, questions and conjecture have arisen about the patterns and types of fires that occurred: highly destructive crown fires at long intervals or creeping ground fires at short intervals. Confounding this problem are great differences among the types of forests found in this region (R. and J. Daubenmire 1968; Pfister and others, in press) and probably among their respective "fire ecologies." A review of the literature dealing with fire in the Northern Rocky Mountains is provided by Wellner (1970) and is updated by Arno.[1]

The present study was developed to provide detailed information on historical fire in one small portion of the Northern Rockies. Specifically, the goal was to determine historical frequencies, intensities, and influences of fire on stand structure and composition in various forest types found on the Bitterroot National Forest in west-central Montana. A knowledge of the workings and results of the historical fire regime is an essential element in describing forest ecosystems, development of management alternatives, and planning subsequent programs and projects.

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[1]Arno, Stephen F. Investigation of fire history in the Bitterroot Range, Montana. (In preparation)

METHODS

Fire scars on trees were sampled intensively on three study areas in different parts of the Bitterroot National Forest (fig. 1). Each of these areas includes similar patterns of forest types extending over a broad elevational range (from about 4,000 to 8,000 feet) on a variety of exposures. The three study areas include terrain, forest types, and presumably fire histories that are representative of the 1.2-million-acre Montana portion of the Bitterroot National Forest.

Sampling and analysis techniques were developed on the Onehorse Study Area, and are explained in greater detail in Arno (footnote 1). (A "how-to-do-it" report for determining fire history based on these procedures is in preparation, by Arno and K. Sneck.) The Tolan and West Fork Study Areas were selected to provide a broader geographical basis for interpreting the role of fire in the Bitterroot National Forest. These latter sites were chosen in part because fuel-inventory studies were also being conducted there as part of the Fire in Multiple Use Management Research, Development, and Application Program (USDA Forest Service 1975). Each of the study areas was also chosen to sample unlogged forest at all elevations on a variety of aspects, and to record fire history in the form of fire scars on living trees and fire-initiated age classes of shade-intolerant conifers.

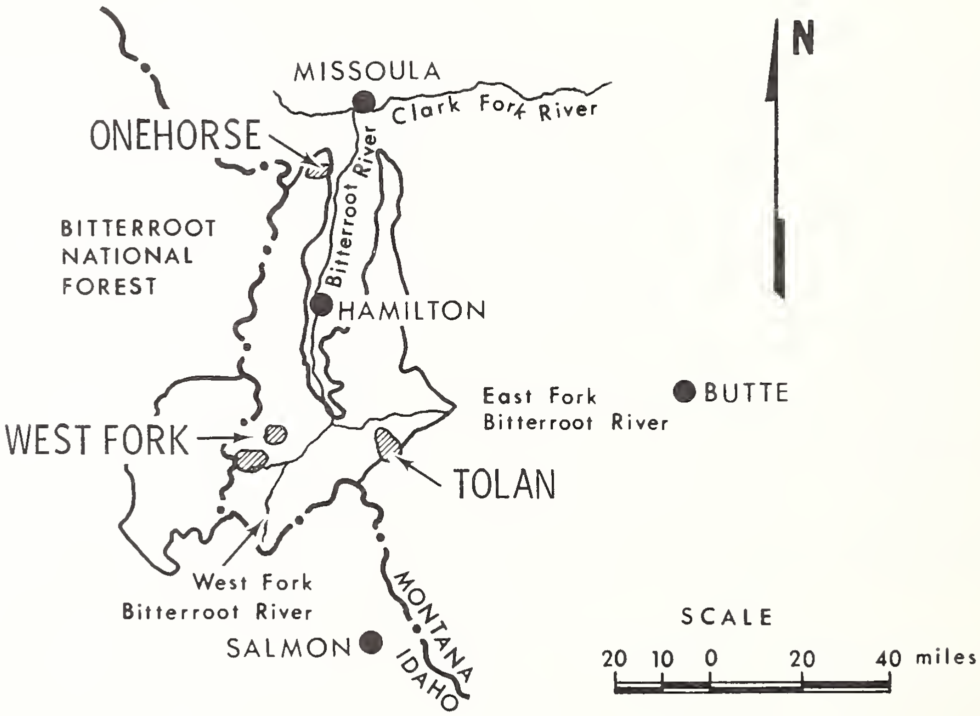

Figure 1.--Location of the three study areas.

Initially, reconnaissance transects were made along roads, trails, and cross-country routes into all major portions of each study area. An attempt was made to visit representative aspects and elevations and not to over-sample narrow, ridgeline ecotones where vegetative types and fire patterns converge. Three types of information were gathered along each transect:

1. Habitat types, identified and mapped according to the Pfister and others (in press) classification.

2. Seral stand types were described and periodically sampled, including increment boring 1 foot above ground level to identify all age classes of shade-intolerant trees. (Corings were counted in the lab.)

3. Fire-scarred sample trees, located and described in terms of number of individual scars and tree soundness (lack of decay).

After the initial reconnaissance, trees in each stand with the largest number of relatively sound fire scars were chosen for sampling. A roller-tipped chain saw was used on large trees to take a cross section of only the wood adjacent to the fire-scar wound. This "partial cross section" resulted in removal of about 10 percent of the basal area of a given large tree. Small or exceptionally rotten trees were felled. Cross sections were sanded, and rings were counted and verified with a binocular microscope (7 to 25 power) to determine the year of each fire scar.

Fire-scar sequences on individual trees were correlated with those from nearby sample trees to obtain a master fire chronology for determining actual fire years. Master chronology years should normally be within ±1 year of the actual fire except for records 250 or more years old, where accuracy diminishes. A sample of several trees is necessary to document the entire sequence of fires in one location, because individual fires often do not inflict a new wound on previously scarred trees (Arno, footnote 1).

The vertical bars in figure 2 show the number of sample trees scarred during each fire year in each of the three study areas. It is evident from the dashed line that sample size diminishes prior to the mid-1700's. This probably accounts for any "apparent" decrease in the fires prior to 1750. In contrast, despite a large sample size, fires diminished in the 1900's. Presumably, this decreasing fire occurrence partially reflects the role of organized fire suppression. Therefore, the interval 1735 to 1900 was considered to provide the best data base for analyzing fire frequencies in the era prior to fire suppression (Arno, footnote 1).

To correlate an adequate number of individual tree records for a given area, it was necessary to calculate fire frequencies for stands of 200 to 800 acres. The boundaries were drawn so that each stand represented only one category of habitat types. The fire record for each stand was thus determined by correlating the individual chronologies from the several sample trees within it. Consequently, the fire frequencies generated in this study (table 1) represent the average intervals between fires detected in a given stand. On one hand it might be argued that these intervals are actually shorter than would be expected for a given smaller stand because some of the fires detected did not cover the entire 200- to 800-acre unit. However, this effect is counterbalanced by the probability that many small or low-intensity fires were not detected in a given stand by the scarred-tree sampling. All evidence considered, these data should give a reasonable approximation of the incidence of fire in a given stand. Frequencies were averaged for all stands in a given habitat-type group in each study area. These habitat-type groups (table 1, columns 1 and 2) serve as a basis for comparison of fire frequencies within as well as among the study areas.

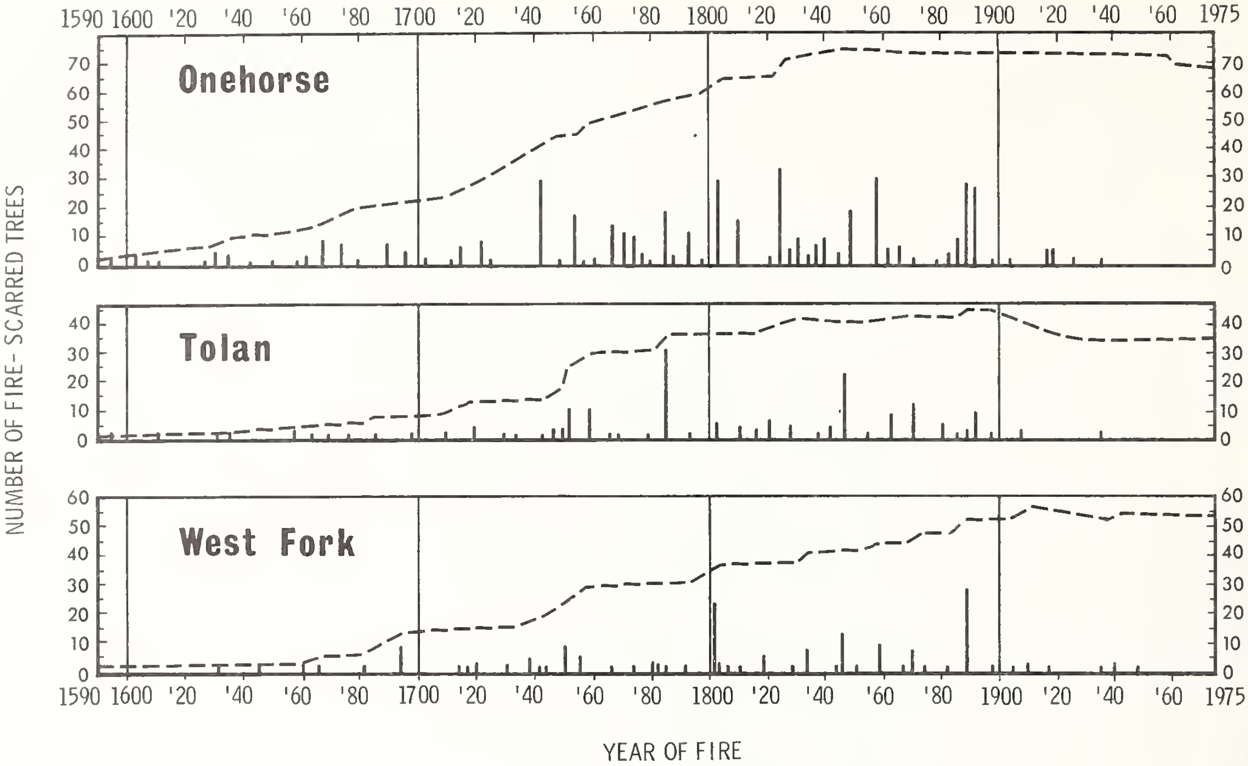

Figure 2.--Forest fire chronologies for the three study areas on the Bitterroot N. F., Montana, showing the number of sample trees scarred each fire-year. Dashed lines indicate the number of fire-susceptible trees (i.e., trees already scarred at least once) in the sample.

Table 1.--Fire frequencies for the period 1735 to 1900 on the three study areas in the Bitterroot National Forest, Montana. Frequencies are based on all fire years identified within 200- to 800-acre habitat type units (stands).

Habitat type groups (potential climax) (Pfister and others, in press)	Descriptive location	General elevations (feet)	Dominant trees: with continued: fire exclusion: (most abundant tree first)	Dominant overstory before 1900 (most abundant tree first)	Onehorse: No. of stands (No. of trees)	Onehorse: Mean fire-free interval (min-max interval)	Tolan: No. of stands (No. of trees)	Tolan: Mean fire-free interval (min-max interval)	West Fork: No. of stands (No. of trees)	West Fork: Mean fire-free interval (min-max interval)
1. Pinus ponderosa/Festuca idahoensis; Pseudotsuga menziesii/Agropyron spicatum; Pseudotsuga/Calamagrostis, P. ponderosa phase	Valley edge	3800-5000	Douglas-fir ponderosa pine	ponderosa pine	1 (11)	6 years (2-20)	1 (4)	11 years (2-18)	1 (7)	10 years (2-18)
2. Pseudotsuga/Physocarpus malvaceus; Pseudotsuga/Calamagrostis (except Cal. phase); Pseudotsuga/Symphoricarpos albus; Pseudotsuga/Vac. globulare (except Xerophyllum phase)	Montane slopes	4200-6200	Douglas-fir	ponderosa pine Douglas-fir lodgepole pine western larch	3 (46)	7 years (2-28)	3 (11)	16 years (4-29)	4 (23)	19 years (2-48)
3. Abies grandis habitat types	Moist canyon	4300-4700	grand fir	western larch lodgepole pine Douglas-fir	1 (7)	17 years (3-32)	--	--	--	--
4. Pseudotsuga/Calamagrostis, Calamagrostis phase; Pseudotsuga/Vac. globulare, Xerophyllum phase; Abies lasiocarpa/Xerophyllum tenax; Abies lasiocarpa/Menziesia ferruginea; Abies lasiocarpa/Linnaea borealis	Lower subalpine slopes	6000-7500	subalpine fir Douglas-fir	lodgepole pine Douglas-fir	1 (9)	17 years (3-33)	3 (16)	27 years (5-62)	3 (13)	28 years (5-67)
5. Abies lasiocarpa/Luzula hitchcockii; Abies lasiocarpa-Pinus albicaulis/Vac. scoparium; Pinus albicaulis-Abies lasiocarpa	Upper subalpine slopes	7500-8600	subalpine fir whitebark pine	whitebark pine lodgepole pine	1 (3)	41 years (8-50)	2 (14)	30 years (4-78)	2 (14)	33 years (2-68

RESULTS AND DISCUSSION

Data Base

A total of 889 individual fire scars (from 171 trees) were documented in the 3 study areas; 726 of these occurred in the 1735 to 1900 period. Ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*), and whitebark pine (*Pinus albicaulis*) all had multiple fire scars dating back as far as 250 to 300 years, although in most areas the lodgepole pine fire-scar records extended back only 150 to 200 years because of stand ages. Ponderosa pine provided the clearest, most abundant, and oldest records in all study areas, with scars as old as 400 years.

The data base is displayed in tables A-1, A-2, A-3, and accompanying figures A-1, A-2, A-3 (appendix A). Table A-1 is the master fire chronology for the Onehorse area, showing the number of sample trees scarred during each fire year in each stand. Figure A-1 shows the locations of those stands and of the sample trees within them. Similarly, the paired fire chronologies and maps present the data for Tolan (table A-2 and fig. A-2) and West Fork (table A-3 and fig. A-3).

Fire Frequency

It seems apparent from tables A-1, A-2, and A-3, and especially as the total number of fire scars per study area is graphed in comparison with sample size in figure 2, that the fire frequencies remained comparably high as far back as the records go--namely, to the early 1600's at Tolan and West Fork and to about the year 1500 at Onehorse. Thus it appears that the fire frequencies during the 1735 to 1900 period represent a pattern continuing back at least to the year 1600.

A logical question that arises is how frequencies based on 200- to 800-acre stands compare with those obtained at a single point on the ground, a single tree. As an example, figure 3 shows the scarred cross section of a ponderosa pine growing on the "montane slopes" (table 1, column 2) at Onehorse. During the 1735 to 1900 period it was scarred by 15 fires at an average interval of every 11 years. This compares with an average interval of 7 years for *stands* in that category (table 1) at Onehorse. Trees growing only a few dozen yards from the one in figure 3 had scars from additional fires. It seems highly unlikely that every fire could burn hot enough at the base of any given tree in such a stand to inflict a new wound, especially when they occurred so frequently as to allow only light accumulations of fuel.

Fires occurred less often in the Tolan and West Fork areas (table 1); thus one might expect individual trees there to be exposed to more intense fires which are more likely to cause a scar. Average pre-1900 fire-free intervals were calculated for the most frequently scarred individual trees in each habitat-type group. These intervals proved to be only about 15 to 20 percent longer than those derived for the entire 200- to 800-acre stands. Even these trees might have missed being scarred in one or two fires, confirming the stand-based estimates.

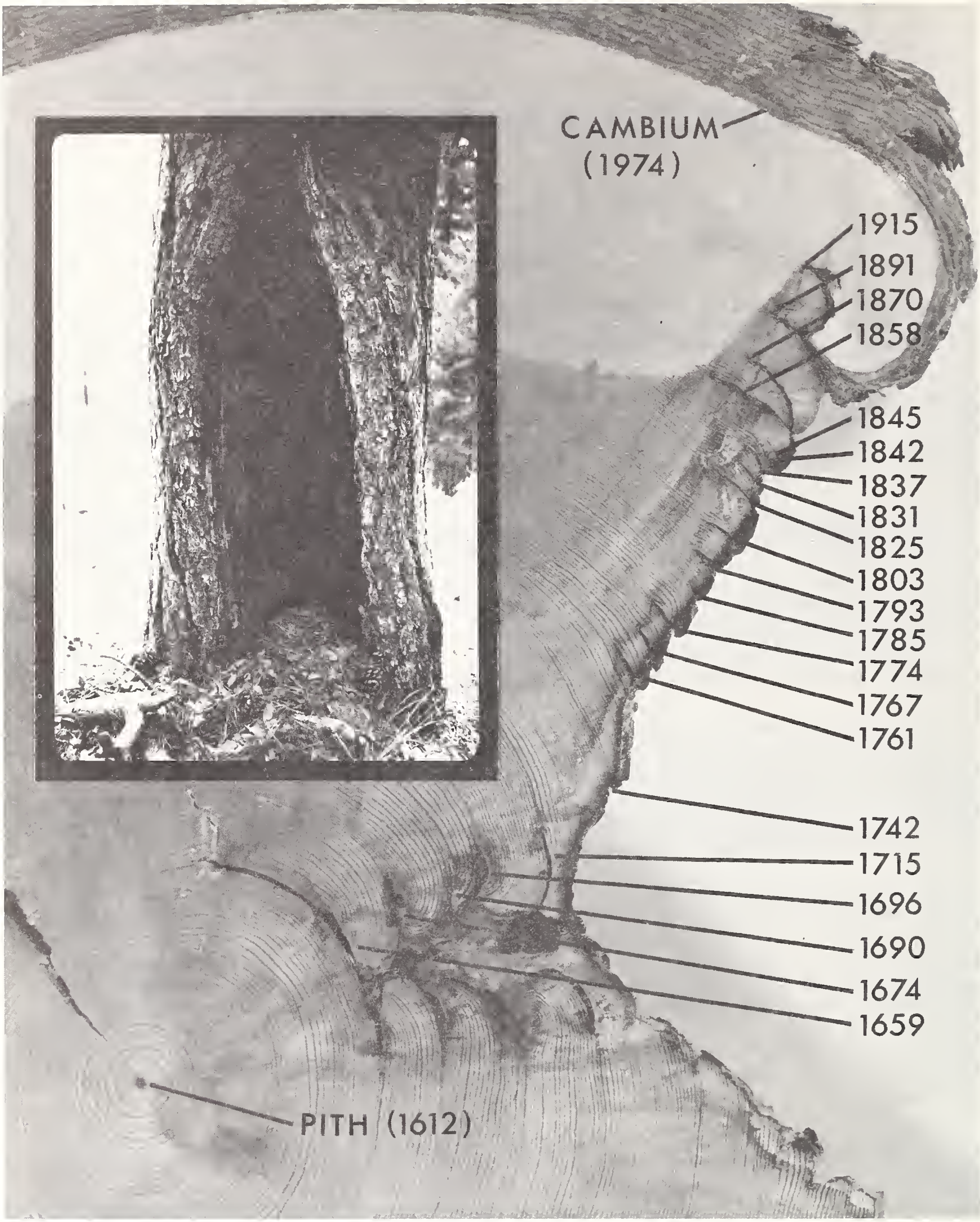

Figure 3.--Multiple fire-scar cross-section, showing 21 fire scars from 1659 through 1915. (Ponderosa pine sample tree #53, Onehorse study area, Bitterroot National Forest)

These historic fire frequencies are compared in table 1 by habitat-type groups for each of the three study areas. For instance, stands on the montane slopes (*Pseudotsuga/ Physocarpus* and other habitat types) had average intervals of 16 and 19 years between fires in the Tolan and West Fork areas, respectively. The shortest interval detected between fires in any of the three stands in this category at Tolan was 4 years. The longest fire-free interval there, during this 1735 to 1900 period, was 29 years. During this period the dominant overstory species was ponderosa pine (table 1, column 5); whereas Douglas-fir would dominate in the absence of fire or other disturbance (column 4). Comparable interpretations can be made for other habitat types using table 1.

Inspection of table 1 reveals that the relative fire frequencies by forest categories are nearly identical at Tolan and West Fork. By contrast, fires occurred almost twice as frequently throughout the Onehorse area--except for the upper subalpine slopes where the sample size was very small, and probably inadequate. One could argue that the Onehorse area is basically drier and therefore burns more frequently, but this reasoning is not borne out by field observations or by the standardized habitat-type categories. A more plausible explanation is that fires originating on the lower slopes at Onehorse spread more readily upward throughout all the types because of the steep topography. However, the data in table 1 show that fire frequencies decrease with increasing elevation at Onehorse at a rate comparable to that of the other areas. Also, such an explanation fails to account for the high frequency of fires on the lowermost units at Onehorse.

Several threads of evidence suggest another reason for the higher fire frequency at Onehorse. Anthropologists have long recognized that Indians historically set fires in the Rocky Mountains (Malouf 1969). Direct descendants of the first settlers in the Sula Valley below Tolan study area (Marvin and William Wetzsteon at Sula, and Mr. Lord at Moosehead Museum, north of Sula, 1975, personal communication.) stated that when their grandparents homesteaded the area near the turn of the century, Indians periodically set forest fires in the nearby mountains, presumably to improve forage production for big game and horses. Indians occupied the Bitterroot Valley for at least several centuries prior to white settlement in the mid-1800's (Ward 1973). According to Dr. C. Malouf, University of Montana, Missoula (personal communication), Indians preferred the main Bitterroot Valley grasslands adjacent to the Onehorse area, therefore aboriginal burning probably would have been more common here than on the rather remote Tolan and West Fork study areas.

Still another tentative suggestion of deliberate aboriginal burning has arisen from Mehringer's (1976) analysis of 12,000 years of pollen and charcoal deposition at Lost Trail Pass Bog (located in the "lower subalpine slopes" category, table 1) 7 miles southwest of the Tolan study area. Mehringer found that airborne charcoal has been deposited continually since the reestablishment of vegetation in the area after glacial retreat 11,500 years ago. Presumably this came from fires burning in a sizable, mostly forested region upwind from Lost Trail Pass. However, the magnitude of charcoal deposition increased dramatically within the last 2,000 years despite no marked change in the forest type. To keep this idea in perspective, one must realize that to hypothesize an Indian-burning program from deposition in one bog is a large extrapolation.

Correlations Among Fire Years

Comparison of the Onehorse data with National Weather Service records between 1870 and 1920 revealed that fires were strongly correlated with drier-than-average summers (Arno, footnote 1). Table A-4 (appendix A) depicts apparent correlations

among the fire years on the three study areas. Evidently, rather extensive fires occurred simultaneously on at least two of the areas during the following years:

1892	1785
1889	1766-67
1870-71	1751-52
1862-63	1720
1858	1715
1846-47	1695-96
1828	1667-68
1802-03	1631-32

Table A-4 also shows that there were a number of years when one area was burned extensively, while the others evidently experienced little or no fire.

Extent and Severity of Fires

It is much more difficult to quantify the intensities of historic fires than it is to simply document their occurrence and determine fire frequency. Still, several sources of data can be interpreted to provide an understanding of the historic role of fire.

Implications of Fire Frequency

The relatively short intervals between fires throughout the three study areas (table 1) suggest that fire intensity was not usually great because there was little time for heavy fuel accumulation.

Age-class Findings

The r's in table A-2, for example, show that many age classes of shade-intolerant conifers were detected wherever age-class analysis was conducted (all stands except A and I). (Some of the regeneration data in table A-2 were provided by Ed Mathews, Northern Forest Fire Laboratory, Missoula, Montana.) Less intensive age-class sampling was done at Onehorse and West Fork, but nevertheless the r's in tables A-1 and A-3 show a similar pattern of multiple age classes of shade-intolerant conifers. Each age class was rather easy to relate to a fire that occurred from 3 to 10 years prior to establishment of the oldest trees in that class.

Some of the age classes detected in a stand apparently resulted from a fire that was not represented as a scar on sample trees in that stand. Fire years 1811 and 1871 in stand F (table A-2) are examples. When the adjacent stands (E and G) had both scars and regeneration dating from those fire years, it seems likely that the fire had in fact visited the stand in question (stand F).

Evidence of Fires of Various Intensities

Both field observations and table A-2 (stand D, 1821 and 1871) suggest that some fires were of such low intensity that little of the lodgepole pine overstory was killed and the stand was not opened sufficiently to allow for establishment of a new age class. This is evidence of a low-intensity, creeping ground fire in lodgepole pine stands. Similar evidence was also observed in many lodgepole forests in all but the northwestern part of Montana during field studies for the forest-habitat-type classification system (Pfister and others, in press). In northwestern Wyoming, Loope and Gruell (1973) found evidence of the historic role of creeping ground fires in lodgepole pine forests. Moreover, they stated that even under high fuel loadings recent fires have remained generally

on the ground except when encountering strong winds or extremely heavy loadings. Moderate upslope winds on steep forested slopes may produce the same effect as strong winds on more gentle terrain.

In general, these interpretations for the Montana portion of the Bitterroot National Forest differ from the view presented by Wellner (1970) that fire damage was "usually extreme" in all major forest ecosystem types in the Northern Rocky Mountains except where ponderosa pine and sometimes where Douglas-fir is the potential climax. The abundance of trees with many fire scars in addition to multiple age classes over most of the landscape in the three study areas suggests that usually fire damage was not extreme.

Forests in the Montana portion of the Bitterroot National Forest are generally less productive and probably less dense than in northern Idaho where Wellner's conclusions seem most applicable. Terrain is often steep, in the Bitterroot especially on the montane slopes (*Pseudotsuga* habitat types, table 1) favoring more-intense burning. However, comparable exposures in northern Idaho, characteristically have more densely forested western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), or grand fir (*Abies grandis*) habitat types; that are evidently more likely to burn in stand-destroying fires. Large holocausts (1910, 1919, Pete King fire in 1934, Sundance and Trapper Peak fires in 1967) have occurred in northern Idaho in this century.

Most researchers are strongly tempted to generalize about fire behavior but perhaps fires in the Northern Rockies are not best described in broad generalizations. Detailed studies of fire history at various places throughout our forest types should ultimately resolve this problem.

Gabriel (1976) recently completed a detailed analysis of the fire history in some lodgepole pine-dominated forests in the Bob Marshall Wilderness of northwestern Montana. In the southern half of his study area, Gabriel documented the occurrence of low-intensity surface fires at 20- to 40-year intervals in each stand. By contrast, he found that larger, stand-destroying fires had profoundly influenced most of the northern half of his study area. However, even here he found about 20 living lodgepole pine and Douglas-fir trees having two fire scars each. This suggests a sporadic pattern of stand destruction even during relatively high intensity fires.

A small proportion of the Onehorse and Tolan areas and a sizable part of the western unit of the West Fork area were apparently burned in high-intensity fires. At Onehorse-a fire-killed stand evidently resulted from a double burn in 1889 and 1892 (Arno, footnote 1). At West Fork a sizable stand was killed in 1889. At Tolan a stand was killed at the head of the canyon bottom (between stands F, G, and H, fig. A-2) in 1785 on a site that was unique in having no evidence of fire having visited it since. In all study areas, the holocaust was restricted to areas within the lower subalpine forest dominated by lodgepole pine (*Abies lasiocarpa/Xerophyllum* and *Abies lasiocarpa/Menziesia* habitat types).

Extent of Fires

Mapping every fire that occurred in a given forest area provides insight into the extent and patterns of historic fire (Heinselman 1973). Unfortunately, such mapping, based on the fire scar and age-class data, could not be done at Onehorse because fires were too frequent. At West Fork, sampling was done in stands that were too dispersed over rugged topography to allow for mapping of individual fires. In contrast, the Tolan data was not hampered by those problems, and the age-class data was ample, thus it was possible to plot the extent of each fire detected in the Tolan drainage between 1900 and 1734 (appendix B).

Although many of these fires were not of high intensity, they were not confined to small areas. In contrast, in recent times, fires of low-to-medium intensity are

suppressed before they cover large areas, whereas high-intensity crown fires may cover large areas. Observations (Kilgore 1975; Mutch 1974) from areas where natural fires have recently been allowed to run their course (White Cap Area, Bitterroot National Forest; Grand Teton and Sequoia-Kings Canyon National Parks), show that low- to medium-intensity fires may cover large areas by advancing sporadically, often slowly, until heavy fall and winter precipitation finally extinguishes them.

Interpretations

The general pattern of fires and age classes in each stand (tables A-1, A-2, and A-3 is clearly one of frequent fires leaving substantial remnants of earlier age classes. Most pre-1900 fires on the Bitterroot study areas apparently burned lightly on drier slopes at lower elevations, perpetuating ponderosa pine as the dominant species in open stands. These fires killed much of the ponderosa pine regeneration and most of the invading Douglas-fir. Fires tended to burn with greater intensity on north-facing slopes, where dense, young growth of Douglas-fir presented more opportunity for carrying a fire above the ground. Even here, however, much of the old-growth ponderosa pine, Douglas-fir, western larch, and even some lodgepole pine survived. In the lower subalpine forest, dominated by lodgepole pine, fires often were of low or medium intensity, spreading mostly on the forest floor. There were occasional hot spots where a stand was largely killed through bole heating or a "run" through the overstory.

Holocausts have also clearly been a part of the spectrum of fires (Sleeping Child, Saddle Mountain, and Corn Creek fires in 1960 and 1961) occurring on lower subalpine slopes in the Bitterroot. They are unusually intense fires that had a dramatic effect on thousands of acres of forest.

Still higher, in the upper subalpine forest, fires were least frequent and also less intense, probably because of moister and sparser fuels. Some of these latter fires undoubtedly spread upslope from more favorable burning conditions at lower elevations and then burned less intensely as fuels thinned out and moisture increased.

IMPLICATIONS FOR FIRE MANAGEMENT

Effects of Fire Exclusion

Data from all study areas (tables A-1, A-2, A-3) show a marked decrease in fire since about 1920. Modern, airborne fire-suppression techniques theoretically can result in very effective control of potentially low-to-medium intensity fires. Thus a major ecological force has been largely excluded for half a century, and the years since the last burn on most of the forested land now exceed the longest fire-free intervals recorded between 1735 and 1900 (table 1). In some forest types, this has allowed fuels to accumulate. In many stands were Douglas-fir is the potential climax tree, dense understories of this species have developed, making a ladder of fuels that now endangers even the fire-resistant, old-growth overstory of ponderosa pine, Douglas-fir, and western larch. Throughout the subalpine forest on the Bitterroot, additional heavy fuels have been generated as a result of massive overstory kills of lodgepole and whitebark pines by the mountain pine beetle (*Dendroctonus ponderosae*) in the 1920's and 1930's.

Also, severe infestations of dwarf mistletoe (*Arceuthobium* spp.) in Douglas-fir, western larch, and lodgepole pine at various locations on the Bitterroot have contributed to stand stagnation and loss of vigor. Presumably, the effect of dwarf mistletoe adds to the fuel generation rates and thus increases vulnerability of the forest to severe fire damage. This situation is partially a result of fire exclusion. Alexander and Hawksworth (1975) have analyzed current knowledge of the interrelationships between natural fire and dwarf mistletoe infestations, and have commented on possible applications of prescribed fire for control of the parasite. Other possible relationships of continued fire exclusion to insect damage, such as to western budworm in Douglas-fir and mountain pine beetle in overly dense ponderosa pine stands on the Bitterroot, also warrant concern.

Continued fire suppression without fuel management apparently promotes accumulation of fuels as well as greater continuity of fuels over the landscape; this probably favors the development of high-intensity fires.

Means for Reducing Fuels

High fuel loadings eventually will be reduced by decay, fire (wildfire or prescribed fire), or removal. Decay is relatively slow in these cool, dry forests and thus seems inadequate unless augmented by various types of prescribed fire or logging, or a combination. Where resource managers do not establish a fuel reduction program, nature may eventually do so by means of a large, uncontrollable wildfire. Mankind does not generally find this alternative safe or otherwise acceptable. Logging and slash disposal can reduce fuels in many areas. However, in some areas, this may be either uneconomical or unacceptable because of other management goals.

In the latter situation, the prescribed use of fire should be seriously considered for fuel reduction and stand management. Prescribed burning in dense stands on *Pseudotsuga* habitat types has recently been demonstrated on the Lubrecht Experimental Forest in western Montana (Norum 1976). Also, information from the following sources can supply much of the framework necessary for using fire in such stands:

1. Findings of natural fire studies in national parks (Kilgore 1975) and wilderness (Habeck and Mutch 1973; Mutch and Habeck 1975);

2. Techniques developed for managing fire in wilderness (Aldrich 1973);

3. Other current research of the Fire in Multiple Use Management Research, Development, and Application Program (USDA Forest Service 1975).

Fire could be applied when burning conditions are moderate, and are forecast to remain stable, especially in early autumn.

A burning program would require carefully developed fire prescriptions designed to accomplish management objectives, while minimizing unwanted fires (Barrows 1974). After the initial fuel reduction, maintenance of desirable fuel and stand conditions should become less difficult. A fuel management plan might incorporate both prescribed fire and naturally caused fires burning under certain conditions in specified areas. Natural fires not burning as desired would be suppressed.

Extrapolating Fire History

Resource managers should be able to approximate pre-1900 fire frequencies in various parts of the Montana portion of the Bitterroot National Forest by extrapolating from table 1. Most areas of the Forest probably had frequencies comparable to those found at Tolan and West Fork, except that slopes of the Bitterroot and perhaps the Sapphire Range immediately adjacent to the main Bitterroot Valley may have had rates more like those at Onehorse.

The Forest habitat-type map and recent topographic maps will provide the basic information for assigning the appropriate habitat types in table 1 to the land in question. Analysis of the latest timber-inventory data and timber-type maps will be important for obtaining a knowledge of fuels and stand conditions necessary for developing fire management programs.

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APPENDIX A

Fire Frequencies and Sample Tree Locations

Table A-1.--Apparent fire years and the numbers of trees scarred in each stand (200- to 800-acre habitat type units) of the Onehorse study area, Bitterroot National Forest, Montana.

Fire year	Habitat type groups/stands: 1. Valley edge (11)*	2. Montane slopes: A&B (19)	C (10)	D&E (17)	3. Moist canyon (7)	4. Lower subalpine slopes (9)	5. Upper subalpine slopes (3)	Total number of scars (76)
1936	--	1	--	--	--	--	--	1
1926	$1^?$	--	--	--	--	--	--	$1^?$
1919	--	4	--	--	--	--	--	4
1917	--	--	--	4^r	--	--	--	4
1904	--	$--^r$	2	--	--	--	--	2
1898	--	--	--	1	--	--	--	1
1892	--	6^r	1	11^r	4^r	3^r	2	27
1889	$1^?$	10	7	3	2	5	--	$28^?$
1886	$8^?$	$3^?$	--	--	--	--	--	11
1883	--	5	--	--	--	--	--	5
1879	--	--	--	1	--	--	--	1
1871	--	--	--	3	--	--	--	3
1866	6	--	--	--	--	1	--	7
1862	2	1	--	3	--	--	--	6
1858**	3	8	3	11	1	3^r	--	29
1849	2	7	8	1	1	--	--	19
1845	1	--	--	4	--	--	--	5
1840	3	2	--	4	--	1^r	--	10
1837	2	3	1	2	--	--	--	8
1835	1	2	--	--	1	--	--	4
1831	2	3	3	2^r	--	--	--	10
1828	5	2	--	--	--	--	--	7
1825	4	7^r	3	12^r	4^r	2	--	32
1821	3	--	--	--	--	--	--	3
1810	3^r	6^r	4	2^r	1	--	--	16
1803	1	6^r	8	11^r	1	3	--	30
1800	3	5^r	--	--	--	3^r	1	12
1798	2	--	--	--	--	--	--	2
1793	4	3	--	5	--	--	--	12
1788	2	1	--	1	--	--	--	4
1785	3	4	6	5^r	--	$--^r$	1	19
1780	1	--	--	1	--	--	--	2
1777	1	3	--	--	--	--	--	4
1774	1	2	3	5^r	--	--	--	11
1771	3	3	1	--	4^r	--	--	11
1767	4	4^r	1	5	--	1^r	--	15
1761	--	--	--	3^r	--	--	--	3
1757	1	1	--	--	--	--	--	2
1754	4	3^r	8	3	$--^r$	$--^r$	--	18
1749	--	1	--	1	--	--	--	2
1742	5^r	6^r	8	6	2^r	2^r	1	30
1725	1	--	--	--	1	--	--	2
1722	$1^?$	3^r	2	3^r	--	$--^r$	--	9
1715	3	--	2	2	--	--	--	7
1712	--	1	1	--	--	--	--	2
1703	--	2	1^r	1	--	--	--	4
1696	1	--	--	3	1	--	--	5
1690	3^r	1^r	3	1^r	--	--	--	8
1680	--	--	--	--	1	--	--	1
1674	1	--	2	4^r	--	--	1	8
1668	1	3^r	2	1^r	2	$--^r$	--	9
1662	--	1^r	1	1^r	--	$--^r$	--	3
1659	--	--	--	1	--	--	--	1
1650	--	--	1^r	--	--	--	--	1
1643	--	--	--	1^r	--	--	--	1
1635	--	1^r	--	2	1	$--^r$	--	4
1631	--	1^r	1	2	1	$--^r$	--	5
1628	--	--	1	--	--	--	--	1
1611	--	$1^?$	--	--	--	--	--	$1^?$
1608	--	--	--	--	--	--	1	1
1603	--	--	--	--	2	--	--	2
1594	--	--	--	--	1	--	--	1
1590	--	1	--	1	--	--	--	2
1554	--	1	--	--	--	--	--	1
1537	--	--	--	1	--	--	--	1
1531	--	1	--	--	--	--	--	1
1518	--	1	--	--	--	--	--	1
1507	--	1	--	--	--	--	--	1
1496	--	1	--	1	--	--	--	2
1470	--	--	--	$1^?$	--	--	--	$1^?$
1366	--	1	--	--	--	--	--	1
Total scars	93	133	84	136	31	24	7	508

* Number of sample trees.

** May include 1856 fire(s).

^{r} Fires causing conifer regeneration

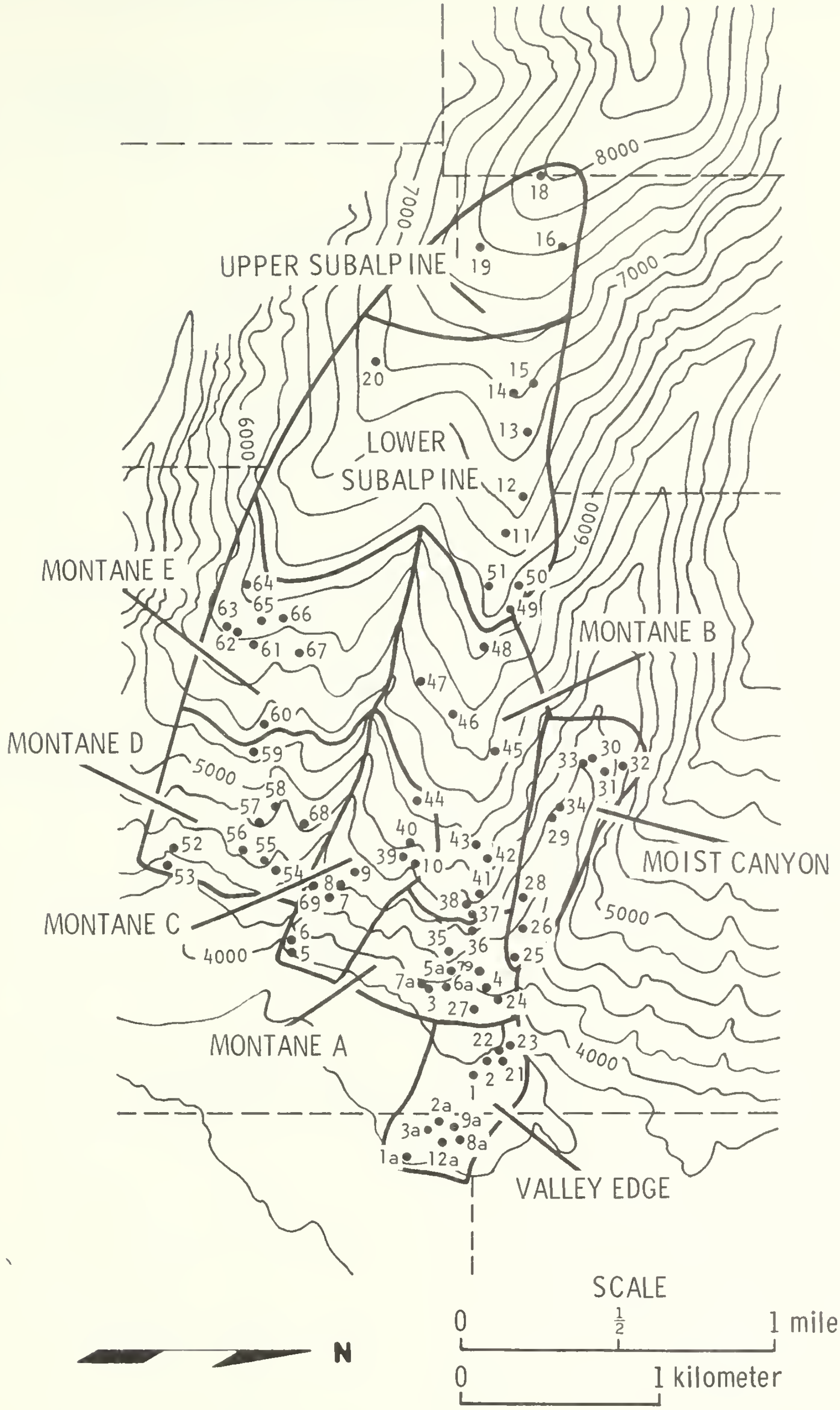


Figure A-1.--Topographic map of the Onehorse study area showing the geographic units and sample-tree locations.

Table A-2.--Apparent fire years and the numbers of trees scarred in each stand (200- to 800-acre habitat type units) of the Tolan study area, Bitterroot National Forest, Montana.

Fire year	1. Valley edge	2. Montane slopes			4. Lower subalpine slopes			5. Upper subalpine slopes		Total number of scars
	A (4)*	B (5)	C (4)	I (2)	D (6)	D (6)	F (4)	G (8)	H (6)	(45)
1935	--	--	--	--	1	--	--	--	--	1
1908	3	--	--	--	1	--	--$^{r?}$	--	--	4
1898	1	--	--	--	--	--	--	--	--	1
1892	4	3^r	--^{r}	1	2^r	--	--$^{r?}$	--	--	10
1889	--	--	--	--	2	--	--	--	$2^{r?}$	4
1886	2	--	--	--	--	--	--	--	--	2
1881	4	2	--	--	--	--	--	--	--	6
1871	3	$1^{r?}$	2	2	1	3^r	--^{r}	1^r	--	13
1863	3	3	1^r	--	2^r	--	--	--	--	9
1855	--	--	1	--	--	--	--	--	--	1
1847	3	3	2	2	5^r	5^r	3^r	--$^{r?}$	--	23
1842	4	--	--	--	--	--	--	1	--	5
1838	--	--	--	1	--	--	--	--	--	1
1828	3	--	2	--	--	--	--	--	--	5
1821	--	2^r	--^{r}	1	3	--	--$^{r?}$	1^r	--	7
1817	3	1	--	--	--	--	--	--	--	4
1811	--	--	--	1	--	1^r	--^{r}	1^r	2^r	5
1803	4	$1^{r?}$	1	--	--	--^{r}	--$^{r?}$	--	--	6
1794	--	1	1^r	--	--	--	--	--	--	2
1785	3	4	--	1	3^r	5^r	4^r	7^r	4^r	31
1779	1	--	--	1	--	--	--	--	--	2
1769	--	--	1	--	--	--	--	--	--	1
1766	2	--	--	--	--	--	--	--	--	2
1757	--	1	--	1	2^r	1	1^r	5	--$^{r?}$	11
1752	--	3	--	1	1	1^r	3	2	--$^{r?}$	11
1750	4	--	--	--	--	--	--	--	--	4
1747	--	1	1^r	--	--	1	--	1	--	4
1743	--	--	--	--	--	--	--	1	--$^{r?}$	1
1734	--	--	1	--	--	1	--	--	--	2
1730	--	--	--	1?	--	--	--	--	--	1?
1720	1	2	--	--	--	--	2	--	--	5
1710	1	--	1	1	--	--	--	--	--	3
1698	--	--	--	--	1	--	--	--	--	1
1686	1	1^r	--	--	--	--	--	--	--	2
1677	--	--	--	--	1	--	--	--$^{r?}$	--	1
1670	--	--	--	--	--	1	--	--	--	1
1664	--	--	1	--	--	--	--	--	--	1
1658	--	--	--	1	2	--	--	--	--	3
1636	--	--	--	--	1	--	--	--	--	1
1632	--	--	--	--	--	--	--	$1^{r?}$	--	1
1611	--	--	1	--	--	--	--	--	--	1
1595	--	--	--	--	--	--	--	$1^{r?}$	--	1
1587	--	--	1	--	--	--	--	--	--	1
1574	--	--	1	--	--	--	--	--	--	1
Total scars	50	29	18	15	28	19	13	22	8	202

* Number of sample trees.

^{r} Fires causing conifer regeneration based on stand age-class samples.

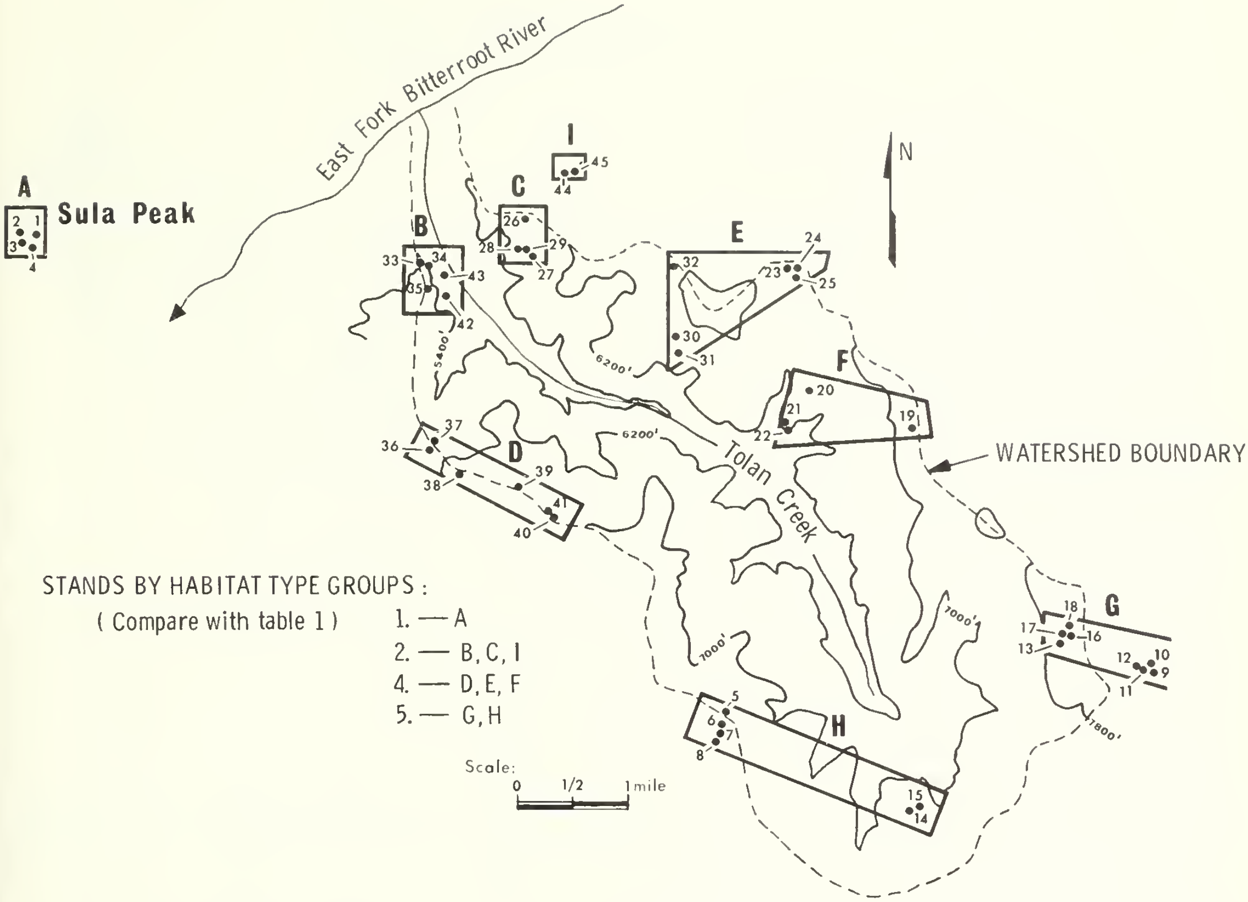


Figure A-2.--Topographic map of Tolan Creek study area (800-ft contour interval) showing sample tree locations.

Table A-3.--Apparent fire years and the numbers of trees scarred in each stand (200- to 800-acre habitat type units) of the West Fork study area, Bitterroot National Forest, Montana.

Fire-year	Habitat type groups/stands: 1. Valley edge: A* (7)**	2. Montane slopes: A* (7)	2. Montane slopes: B (4)	2. Montane slopes: C (5)	2. Montane slopes: D (7)	4. Lower subalpine slopes: E (4)	4. Lower subalpine slopes: F (6)	4. Lower subalpine slopes: G (7)	5. Upper subalpine slopes: H (7)	5. Upper subalpine slopes: I (3)	Total number of scars (50)
1948	1	1	--	--	--	--	--	--	--	--	1
1940	--	--	--	--	--	--	3	--	--	--	3
1935	--	--	--	--	--	--	--	--	1[r]	--	1
1917	--	--	1[r]	--	--	--[r?]	--	--	--	--	1
1910	--[r]	--[r]	--	--	--	--	1[r]	--[r?]	--	--	1
1905	--	--	1[r]	--	2	--	--	--	--	--	3
1898	--	--	--	--	--	--	--	--	1	--	1
1889	5[r]	5[r]	4[r]	3	6[r]	2[r]	4[r]	3[r]	1[r]	--[r]	28
1882	--	--	--	--	1	--	--	--	--	--	1
1875	1[r]	1[r]	--[r]	--	--	--	--	1	--	--	2
1870	--	--	--	4	--	--	--[r?]	--	2[r?]	--	6
1867	2	2	--	--	--	--	--	--	--	--	2
1859	2	2	2	--	1	1[r]	--[r?]	--	--	1	7
1851	2	2	--	--	--	--	--	--	--	--	2
1846	1[r]	1[r]	4[r]	--	6[r]	--	--	--	--	2[r]	13
1844	2	2	--	--	--	--	--	--	--	--	2
1841	--	--	--	1	--	--	--	--	--	--	1
1834	--	--	3	--	2[r]	--	1	--	2	--	8
1829	1	1	--	--	--	--[r?]	--	--	--	2[r]	3
1819	2	2	4	--	--	--	--[r]	--	--	--	6
1811	1	1	--	--	--	--	--	--	--	--	1
1807	--	--	--	--	--	1[r]	--	1[r]	--	--	2
1804	--	--	--	2	--	--	--	--	--	--	2
1802	5	5	4	--	6	2	1	3	1	1[r?]	23
1792	--	--	2[r]	--	--	--	--[r?]	--	--	--	2
1785	2	2	--	--	1	--	--	--	--	--	3
1783	--	--	--	--	2	--	--	--	--	--	2
1781	--	--	1	--	2	--	--	--	--	1	4
1774	--	--	--	--	--	--	--	--	--	1	1
1767	2	2	--	--	--	--	--	--	--	--	2
1761	--	--	--	--	--	--	--	--	--	1	1
1756	2	2	--	3	--	--	--	--	--	--	5
1751	2	2	2[r]	--	4	1	--	--	--	1	10
1744	--	--	--	--	--	--	--	1	--	--	1
1742	--	--	--	--	--	--	--	--	--	1	1
1739	2	2	1[r]	--	1	--	--	--	--[r?]	--	4
1731	--	--	--	--	1	--	--	--	--	--	1
1720	--	--	--	1	--	--	--	--	--	1	2
1718	--	--	--	--	--	--	--	--	--	--	--
1715	--	--	--[r]	--	--	--	--	--	1	1	2
1695	1	1	2[r]	--	1	1	--	--	2	1	8
1682	--	--	--	1	--	--	--	--	--	--	1
1667	--	--	--	--	--	1	--	2	--	--	3
1660	--	--	1	--	--	--	--	1	--	--	2
1646	--	--	1	--	--	--	--	--	--	--	1
1632	--	--	1	--	1	--	--	--	--	--	2
1573	--	--	--	--	1	--	--	--	--	--	1
Total scars	36	36	34	15	38	9	10	12	11	14	179

* Stand A represented both habitat type groups but is not repeated in calculating the total column.

** Number of sample trees.

[r] Fires causing conifer regeneration.

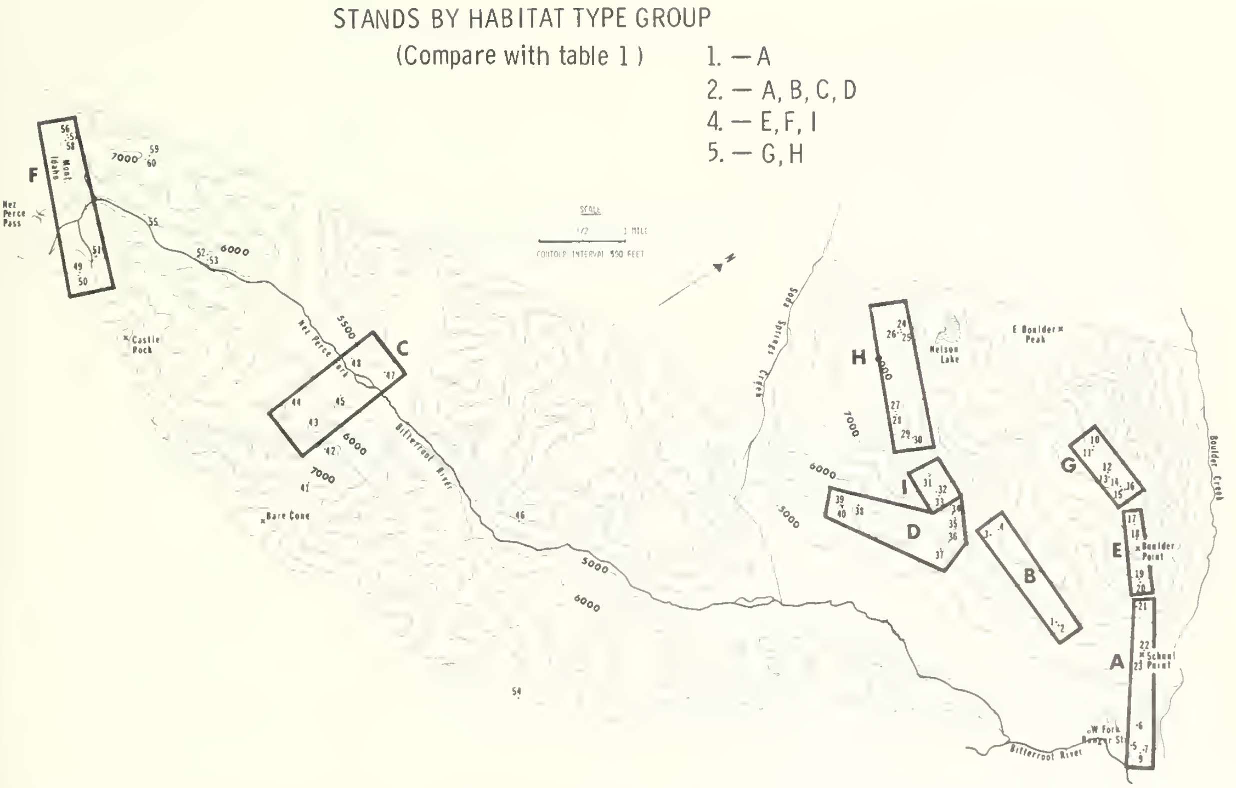


Figure A-3.--Topographic map of West Fork study area, Ravalli County, Montana, showing sample tree locations.

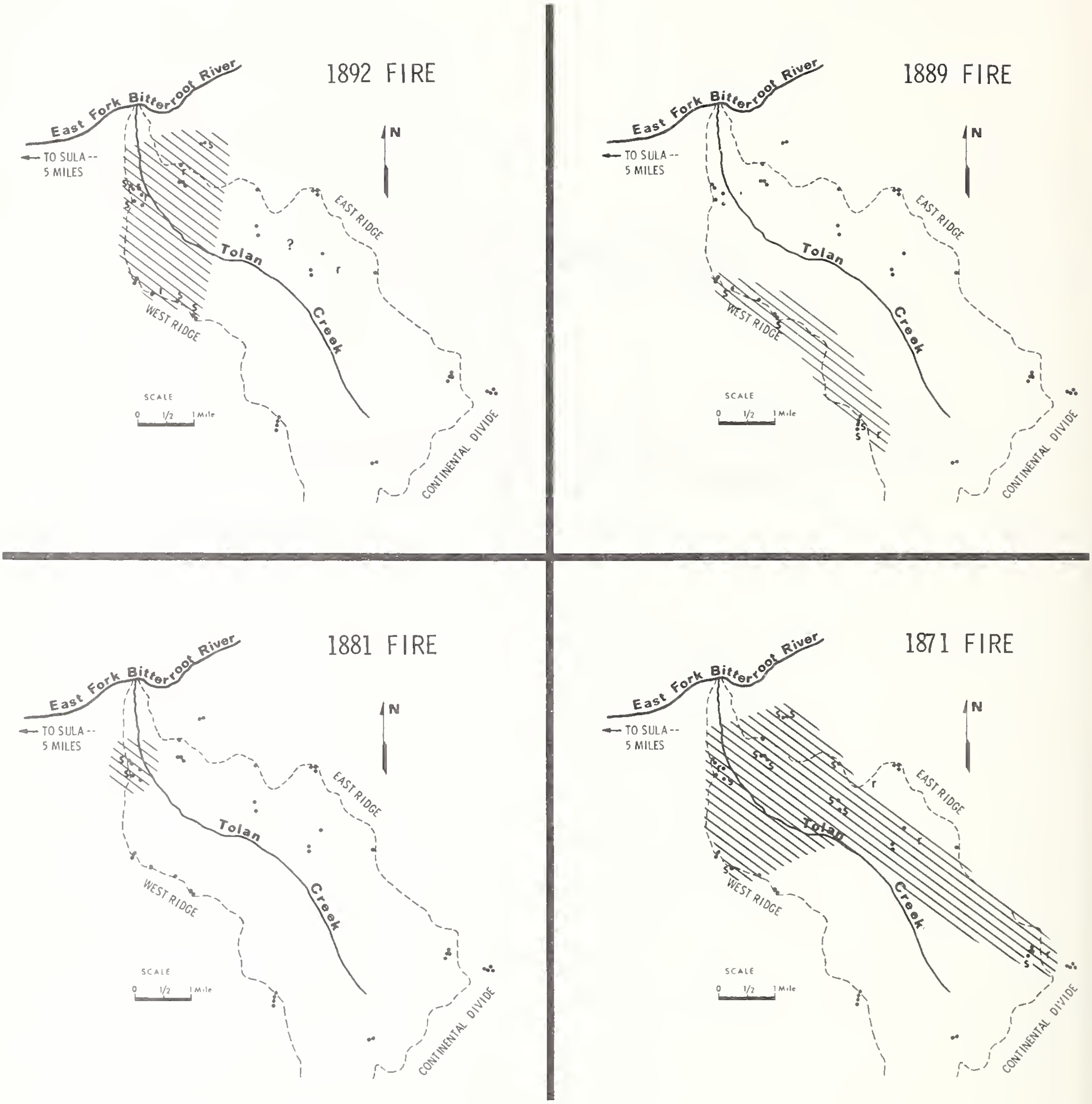
Table A-4.--Number of sample trees scarred by year for each of three study areas on the Bitterroot National Forest, Montana. Fire-year correlations among the study areas are underlined. (n = number of sample trees)

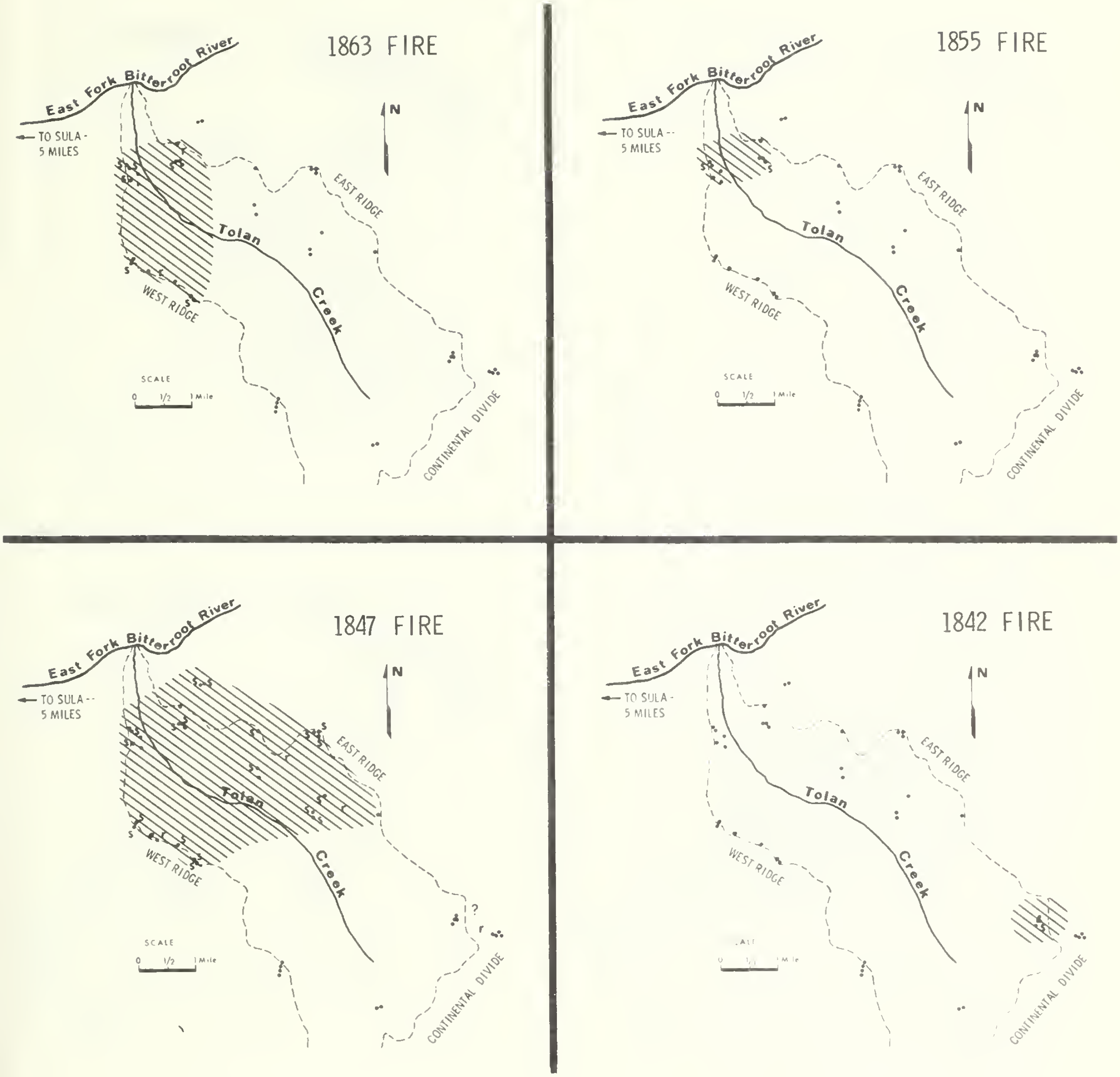
Fire-year	Onehorse n=78	Tolan n=45	West Fork n=59
1948			1
1940			3
1936	1		
1935		1	1
1926	1?		
1919	4		
1917	4		1
1910			4
1908		4	
1905			3
1904	2		
1898	1	1	1
1892	28	10	
1889	29	4	29
1886	11	2	
1883	5		
1882			1
1881		6	
1879	1		
1875			2
1871	3	13	
1870			8
1867			2
1866	7		
1863		9	
1862	6		
1859			10
1858	31		
1855		1	
1851			2
1849	19		
1847		23	
1846			14
1845	5		
1844			2
1842		5	
1841			2
1840	10		
1838		1	
1837	8		
1835	4		
1834			8
1831	10		
1829			3
1828	7	5	
1825	34		
1821	3	7	
1819			6
1817		4	
1811		5	1
1810	16		
1807			2
1804			4
1803	31	6	
1802			24
1800	12		
1798	2		
1794		2	
1793	12		
1792			2
1788	4		
1785	19	31	3
1783			3
1781			4
1780	2		
1779		2	
1777	4		
1774	11		1
1771	12		
1769		1	
1767	15		2
1766		2	
1761	3		1
1757	2	11	
1756			6
1754	18		
1752		11	
1751			10
1750		4	
1749	2		
1747		4	
1744			1
1743		1	
1742	30		1
1739			5
1734		2	
1731			1
1730		1?	
1725	2		
1722	9		
1720		5	2
1717			1
1715	7		2
1712	2		
1710		3	
1703	4		
1698		1	
1696	5		
1695			9
1690	8		
1686		2	
1682			1
1680	1		
1677		1	
1674	8		
1670		1	
1668	9		
1667			3
1664		1	
1662	3		
1660			2
1659	1		
1658		3	
1650	1		
1646			1
1643	1		
1636		1	
1635	4		
1632		1	2
1631	5		
1628	1		
1611	1?	1	
1608	1		
1603	2		
1595		1	
1594	1		
1590	2		
1587		1	
1574		1	
1573			1
1554	1		
1537	1		
1531	1		
1518	1		
1507	1		
1496	2		
1470	1?		
1366	1		
Totals	516	202	198

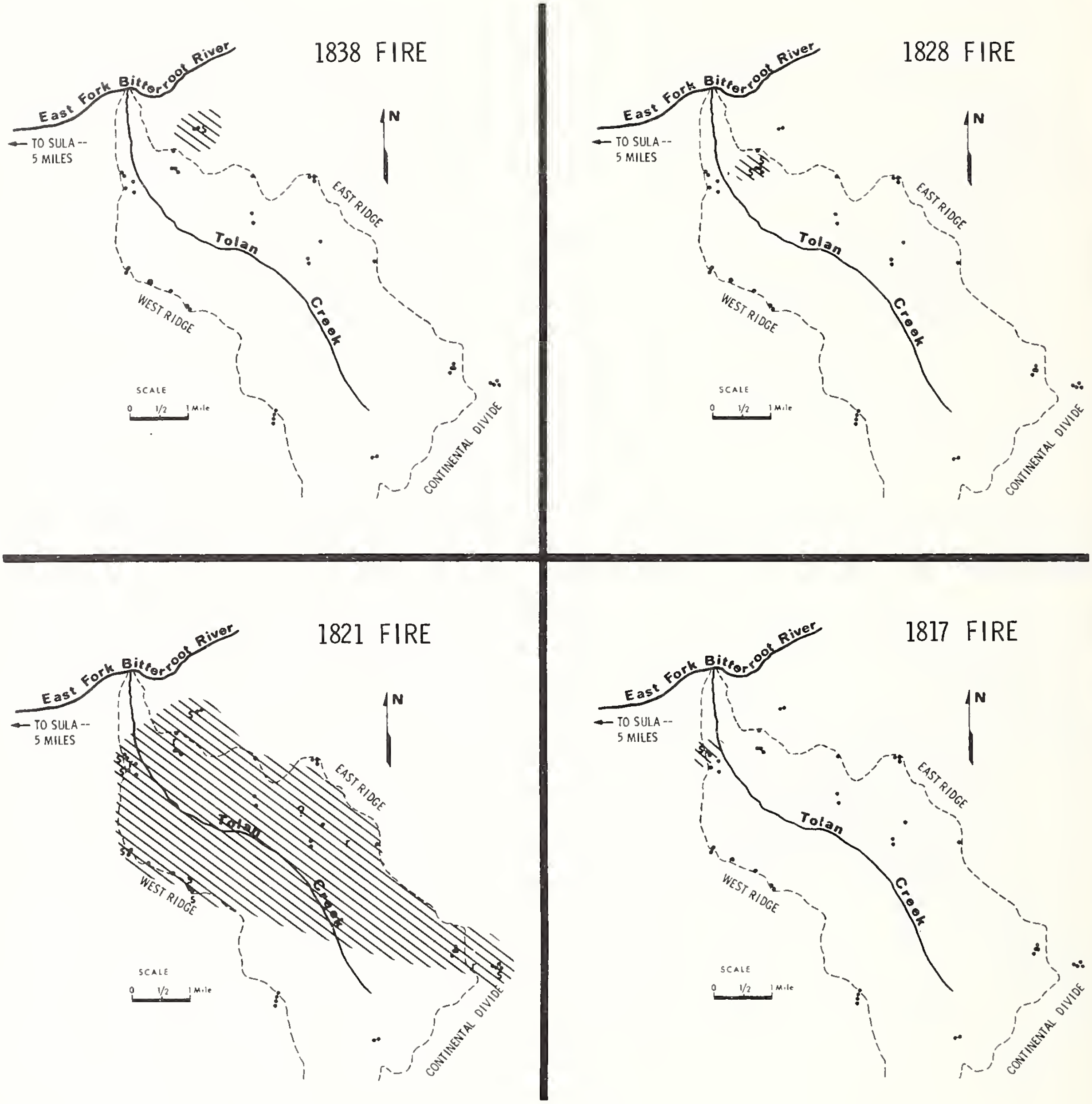
APPENDIX B

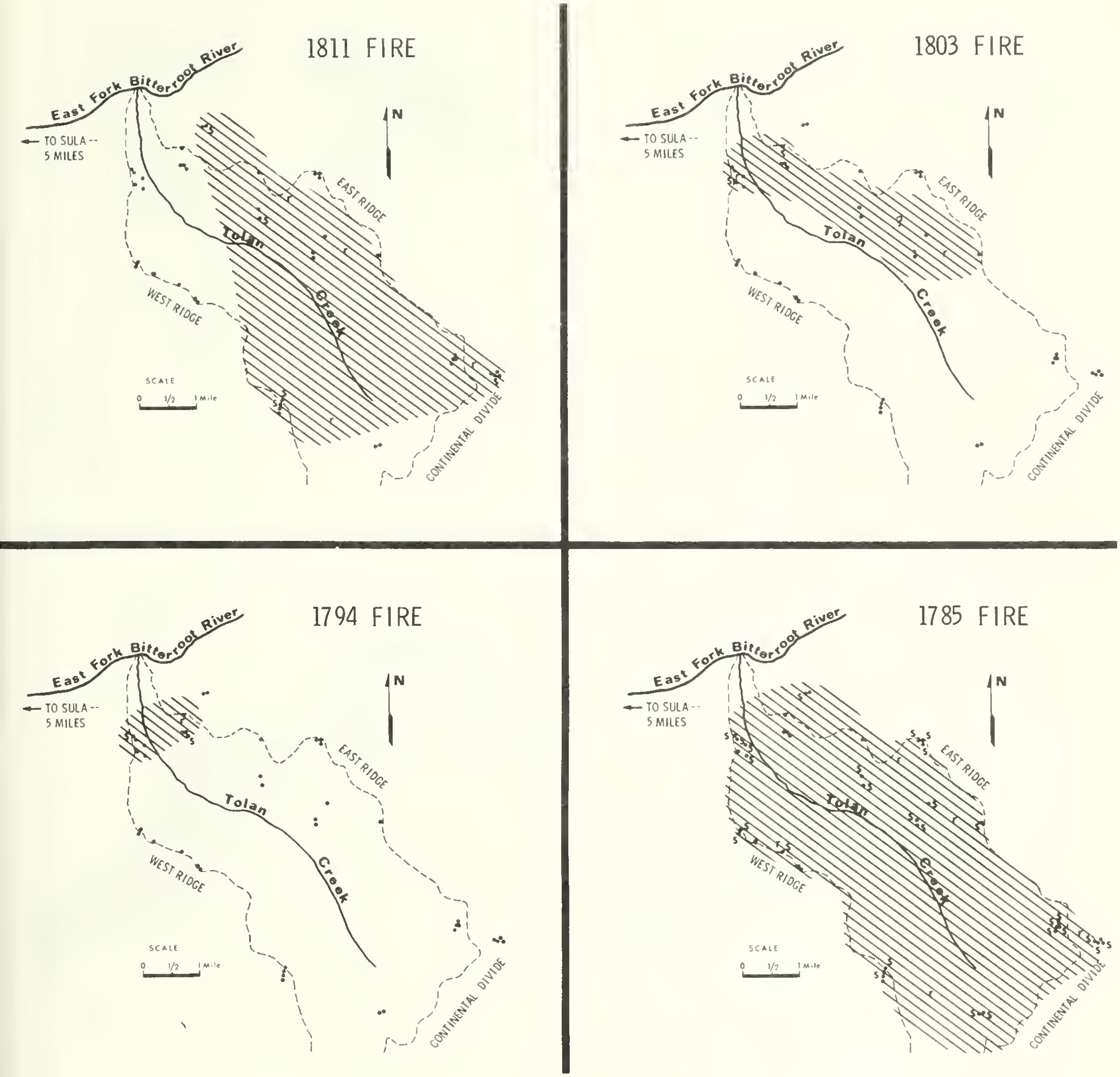
Area Covered by Individual Fires, Tolan Creek, 1900-1734

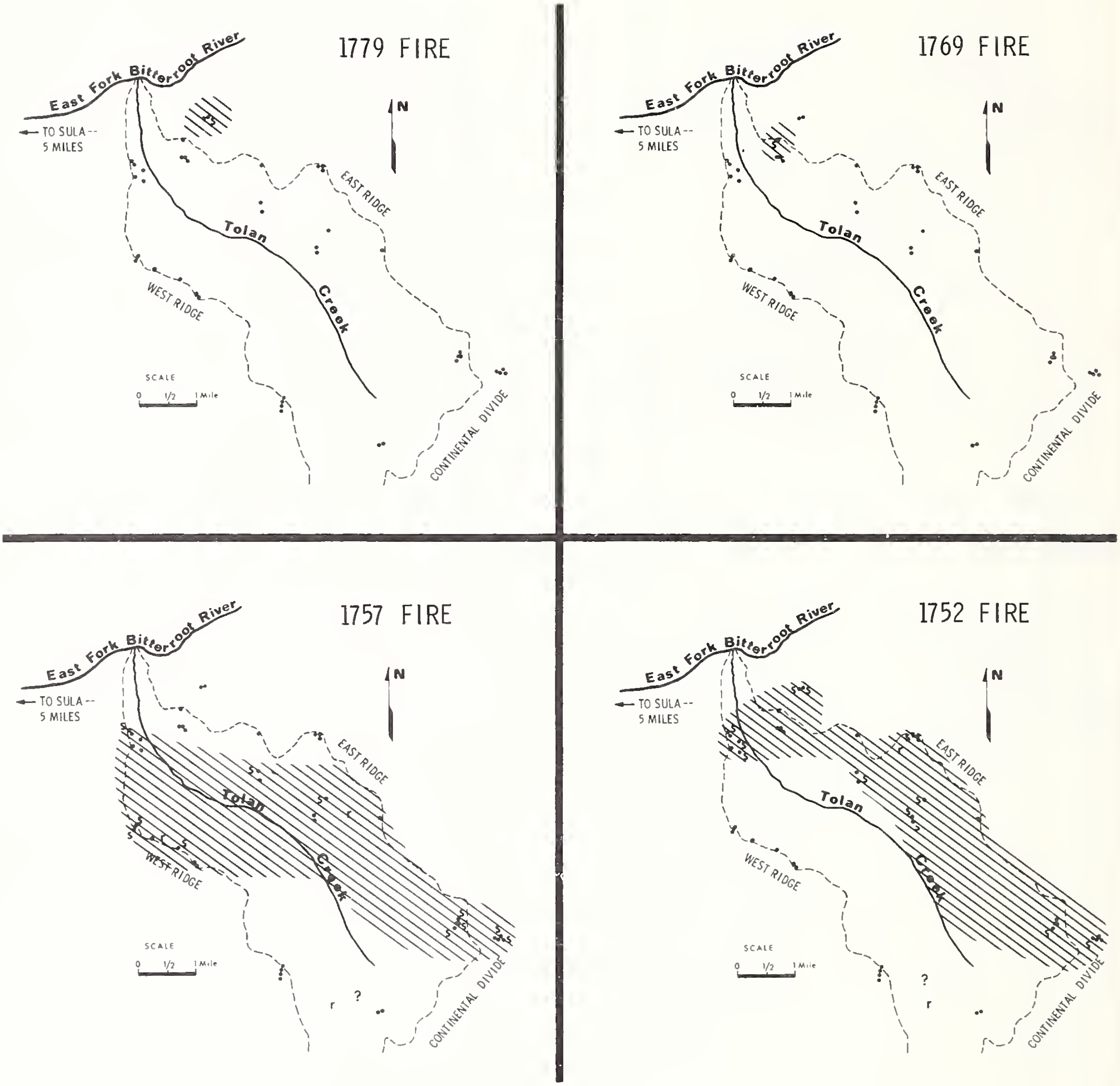
Dots show sample tree locations.
s = scar on that tree that year.
r = regeneration from that fire
detected in the stand.

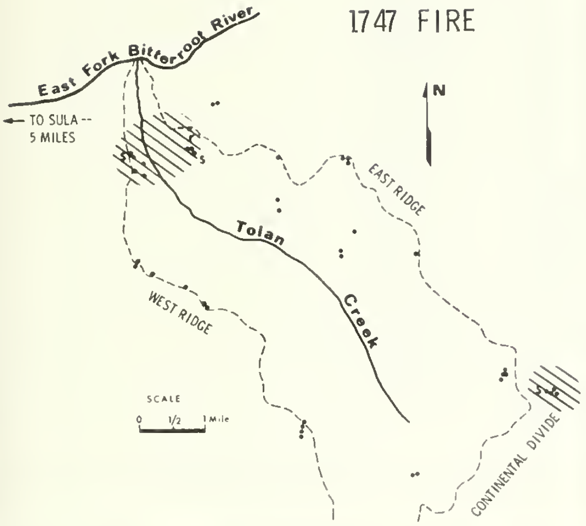

1892 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
Tolan Creek
EAST RIDGE
WEST RIDGE
CONTINENTAL DIVIDE
SCALE
0 1/2 1 Mile
1889 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
Tolan Creek
EAST RIDGE
WEST RIDGE
CONTINENTAL DIVIDE
SCALE
0 1/2 1 Mile
1881 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
Tolan Creek
EAST RIDGE
WEST RIDGE
CONTINENTAL DIVIDE
SCALE
0 1/2 1 Mile
1871 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
Tolan Creek
EAST RIDGE
WEST RIDGE
CONTINENTAL DIVIDE
SCALE
0 1/2 1 Mile

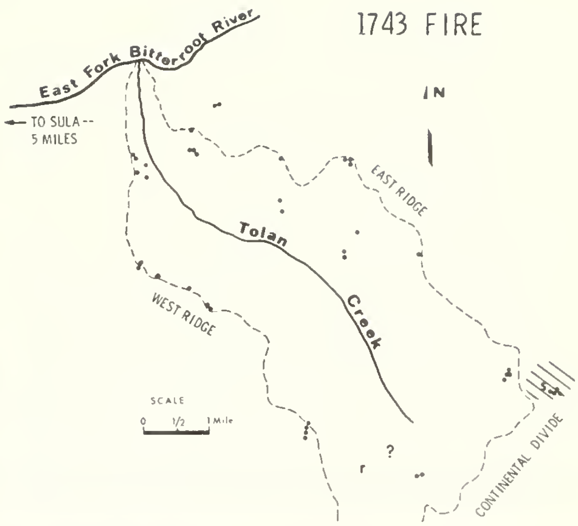

1863 FIRE
East Fork Bitterroot River
TO SULA - 5 MILES
N
EAST RIDGE
WEST RIDGE
Tolan
Creek
CONTINENTAL DIVIDE
SCALE
0 1/2 1 Mile
1855 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
WEST RIDGE
Tolan
Creek
CONTINENTAL DIVIDE
SCALE
0 1/2 1 Mile
1847 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
WEST RIDGE
Tolan
Creek
CONTINENTAL DIVIDE
SCALE
0 1/2 1 Mile
1842 FIRE
East Fork Bitterroot River
TO SULA - 5 MILES
N
EAST RIDGE
WEST RIDGE
Tolan
Creek
CONTINENTAL DIVIDE

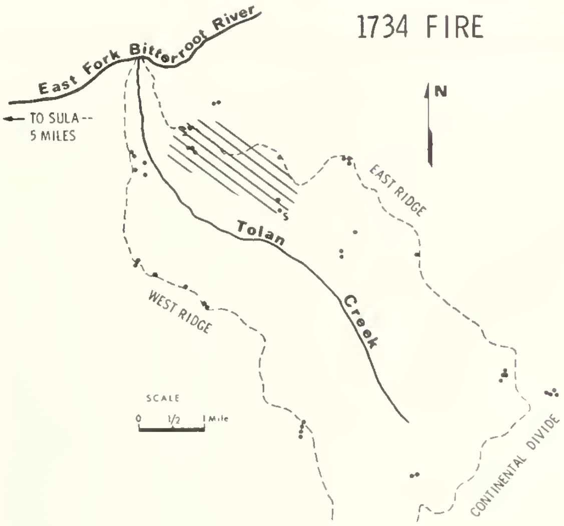

1838 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
Tolan Creek
WEST RIDGE
SCALE
0 1/2 1 Mile
CONTINENTAL DIVIDE
1828 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
Tolan Creek
WEST RIDGE
SCALE
0 1/2 1 Mile
CONTINENTAL DIVIDE
1821 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
Tolan Creek
WEST RIDGE
SCALE
0 1/2 1 Mile
CONTINENTAL DIVIDE
1817 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
Tolan Creek
WEST RIDGE
SCALE
0 1/2 1 Mile
CONTINENTAL DIVIDE


1811 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
WEST RIDGE
Tolan Creek
SCALE
0 1/2 1 Mile
CONTINENTAL DIVIDE
1803 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
WEST RIDGE
Tolan Creek
SCALE
0 1/2 1 Mile
CONTINENTAL DIVIDE
1794 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
WEST RIDGE
Tolan Creek
SCALE
0 1/2 1 Mile
CONTINENTAL DIVIDE
1785 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
WEST RIDGE
Tolan Creek
SCALE
0 1/2 1 Mile
CONTINENTAL DIVIDE


1779 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
Tolan Creek
WEST RIDGE
SCALE
0 1/2 1 Mile
CONTINENTAL DIVIDE
1769 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
Tolan Creek
WEST RIDGE
SCALE
0 1/2 1 Mile
CONTINENTAL DIVIDE
1757 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
Tolan Creek
WEST RIDGE
SCALE
0 1/2 1 Mile
CONTINENTAL DIVIDE
1752 FIRE
East Fork Bitterroot River
TO SULA -- 5 MILES
N
EAST RIDGE
Tolan Creek
WEST RIDGE
SCALE
0 1/2 1 Mile
CONTINENTAL DIVIDE







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Arno, Stephen F.
1976. The historical role of fire on the Bitterroot National Forest. USDA For. Serv. Res. Pap. INT-187, 29 p. Intermountain Forest and Range Experiment Station, Ogden, Utah 84401.

Presents frequencies, intensities, and influences of fire on stand structure and composition on the Bitterroot National Forest in west-central Montana. Three study areas were established, each having a wide range of elevations and forest types. Findings are based upon study of nearly 900 individual fire scars on living trees, and on age-classes of shade-intolerant trees attributable to fire.

KEYWORDS: fire ecology, fire frequency, forest succession, habitat types.

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